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GROWING PLUMS IN CALIFORNIA

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TO BE FULLY PRODUCTIVE A PLUM ORCHARD MUST BE

- Well planned from its beginning
- Well managed during its lifetime

THE CROP ALSO MUST BE PROPERLY TAKEN CARE OF AFTER HARVEST AND THIS REQUIRES KNOWLEDGE OF

- Handling
- Packing
- Cooling
- Marketing

THIS PUBLICATION DISCUSSES EACH OF THESE VITAL FACTORS. USEFUL ILLUSTRATIONS ARE INCLUDED.

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GROWING PLUMS IN CALIFORNIA

Native species of plums are found in most areas of the North Temperate Zone throughout the world. Of these, certain varieties of the American species *Prunus americana* are productive and hardy, although the fruits are small and too soft to be commercially valuable. European plums, *P. domestica,* were brought to the United States by early settlers and today California's dried-prune industry is based on varieties of this group. The Japanese plum *P. salicina* (native to China but domesticated in Japan about 400 years ago) was brought to California in 1870 and the first introductions were improved by Luther Burbank. Today, plums grown in California are the result of chance seedlings and controlled breeding programs utilizing Burbank's original introductions and their progeny. Over 100 varieties of plums are grown in the state and most of them are Japanese. The major use of European plums is for drying, although a few varieties of such plums are grown for fresh consumption.

Plum refers to varieties belonging mainly to the Japanese plum group for fresh consumption and not for drying; plums are also used for canning, freezing, and jam and jelly making.

Prune refers to plums dried whole without fermentation at the pit and characterized by a high sugar content. Prune-type plums are used primarily for drying, but some varieties are canned or shipped to fresh markets.

California plum production is located in three producing areas: South San Joaquin District, Sacramento District and Placer District.

Over 90 per cent of California's plum production is concentrated in the South San Joaquin District in Tulare, Fresno and Kern Counties, with minor production in Kings, Madera and Merced Counties. Sacramento District Counties include San Joaquin, Sutter, Sacramento, Yolo, Solano and Stanislaus. The Placer District includes Placer, El Dorado and Nevada Counties.

ESTABLISHING THE ORCHARD

Choosing the right plum variety or varieties is perhaps the most important decision in establishing a new orchard for it will influence the profit potential of the orchard over a number of years, and thus must be considered as a long-term investment. The grower should also decide whether he wants a sequence of varieties ripening through the whole season in order to continually supply markets and maintain a constant labor force, or whether he wants to fill in certain seasonal production gaps. In California, plum varieties ripen from May to October. Most varieties are adapted to long-term shipment, but a few are tender and are best for local markets.

European plums

Most European plums grown in California today are used for drying, with the French variety the most widely planted. Present commercial varieties used for fresh consumption include, President, Standard, Tragedy, and Empress. The Italian Prune is popular in Oregon, Washington and Idaho, but not California. Other groups of European plums grown in past years in-

clude: Green Gage, Yellow Egg, Lombard and Imperatrice (blue) plums.

European plums require 800 to 1100 hours below 45° F winter chilling for leaf and flower buds to break dormancy in the spring; Japanese plums require less. President plum sometimes exhibits delayed foliation and flower bud drop due to lack of winter chilling. The normal bloom period for European plums is slightly later than that of Japanese plums. Bloom starts in early March and continues into early April, and dates vary with variety, season, and district.

Some European varieties have a tendency toward alternate bearing. The year following a heavy crop is often characterized by less bloom and lower yields. While some European plum trees are characteristically large and vigorous growers, there is considerable variation among varieties. For example, President tends toward long, slender, upright shoots, and Standard is compact and has greater spur development. Leaves are large and thick, glossy dark-green above, and pale green with considerable pubescence beneath. Fruit is borne largely on spurs and is variable in size, color, and shape in addition to being clingstone or free.

Japanese plums

Kelsey was the first variety of *P. salicina* brought from Japan to California in 1870, but other varieties were soon introduced into California from both Japan and Europe. Japanese plum trees are distinguished from European plums by leaves which are medium-sized and, usually, sharp-pointed; their leaves also are free from hair on lower surfaces. Trees bloom in late February and into March (earlier than European plums) and thus are more susceptible to frost injury. Most Japanese plum varieties are as resistant to winter cold as peaches are, and can be grown in most fruit growing areas in California.

Fruits of Japanese varieties are usually large and heart-shaped, often with a pronounced apex which distinguishes them from other types of plums (there are, however, a few varieties which are oblate or round). The outside of the fruit may be dark to bright red, green, yellow, purple, or black, but never blue. The flesh is yellow, red, or amber.

Tree-growth habits vary considerably among varieties; some are low and spreading, while others have extremely upright growing characteristics. Flowers are produced three in a bud on either 1-year-old shoot or spur growth. Fruit set is heavier and more consistent on spurs.

The chilling requirement for leaf and flower buds of most varieties of Japanese plums is generally 700 to 1000 hours. Bloom and leaf development occasionally will be delayed in areas where warm winter temperatures have occurred. Maturity dates of commercial Japanese varieties spread from mid-May into October. Many new selections are introduced each year and are slowly replacing older, less desirable varieties.

Site selection and preparation

Deep sandy loam soils with good internal drainage and freedom from alkali or salinity are best for optimum plum tree growth and production. Adequate growth and production can be obtained on a fairly wide range of soil types but careful selection of rootstocks is important. Ample good-quality irrigation water is necessary, as plum trees will not produce commercially acceptable crops under arid California conditions without supplemental irrigation water.

Because plums bloom early in the season and are subject to spring frosts, relatively higher sites with good air drainage are desirable. Low-lying cold sites should be avoided.

Most plum orchards are either fur-

LEADING COMMERCIAL PLUM VARIETIES IN CALIFORNIA

Variety	Earliest shipping date, week-month	Requires pollenizer	Tree shape	Fruit shape	Skin color when ripe	Flesh color
Ace	2 July	Yes	Moderate spreading	Heart	Mottled greenish-yellow to crimson	Crimson to red
Beauty	4 May	No†	Upright	Heart	Greenish-yellow to bright crimson	Amber streaked with scarlet
Burmosa	1 June	Yes	Spreading	Semi-heart to round	Yellow with red blush	Light amber
Casselman	1 Aug.	No†	Upright	Conical	Purplish-crimson	Yellow
Duarte	1 July	Yes	Upright	Heart	Dull red, brown spots, heavy bloom	Red
El Dorado	4 June	Yes	Very upright	Flat-oval	Dark red with purple tint	Yellow
Elephant Heart	3 July	Yes	Upright	Heart	Mottled greenish-yellow with red spots to purplish-red	Red
Friar	4 July	Yes	Upright	Flat-oval	Black	Amber
Frontier	4 June	Yes	Moderate upright	Heart	Purple-black	Red
Grand Rosa	4 July	No	Upright	Conical	Red to purplish-red	Yellow
July Santa Rosa	4 June	No	Upright	Conical	Bright purplish-red	Yellow
Kelsey	3 July	Yes	Moderate upright-moderate vigor	Heart	Green to yellow	Greenish-yellow
Laroda	2 July	Yes	Upright	Conical	Dark red to purple	Yellow

(continued)

Variety	Earliest shipping date, week-month	Requires pollenizer	Tree shape	Fruit shape	Skin color when ripe	Flesh color
Late Santa Rosa	1 July	No†	Upright	Conical	Resembles Santa Rosa with dark suture line	Yellow with red near skin
Mariposa	4 June	Yes	Upright	Heart	Mottled greenish-yellow with red spots	Red
Nubiana	2 July	Yes	Moderate upright	Flat-oval	Purplish-black	Yellow
President*	4 July	Yes	Upright-spreading	Oval	Dark purple	Yellow
Queen Ann	3 July	Yes	Moderate upright-moderate vigor	Heart	Purplish-black	Light yellow
Queen Rosa	3 June	Yes	Moderate upright	Round	Red to purplish red	Yellow, reddish near skin
Red Beaut	3 May	Yes	Upright-spreading	Conical	Bright red	Yellow
Redroy	1 July	No†	Upright-moderate vigor	Conical	Bright red	Yellow
Roysum	2 Sept.	No	Upright	Conical	Light purple	Yellow with red near skin
Santa Rosa	2 June	No†	Upright	Conical	Purplish-crimson	Amber with red near skin
Simka	2 July	No	Moderate spreading	Heart	Ebony	Yellow
Standard*	1 Aug.	Yes	Upright-moderate vigor	Oval	Purple, heavy blue bloom	Yellow
Tragedy*	3 June	Yes	Spreading	Oval	Dark blue to purple	Greenish-yellow
Wickson	4 June	Yes	Moderate upright	Heart	Greenish-yellow with red tinge, white bloom	Bright yellow

* European.
† Cross pollination may increase set in some areas.

row or flood irrigated, so land must be leveled to grade before planting. Ripping to a depth of at least 4 feet on hardpan soils is recommended. If plums are to be planted where plow pan or shallow soil compaction layers exist, the site should be chiseled to about 20 to 24 inches before leveling. Following ripping or chiseling the orchard site should be irrigated and "floated" to locate and relevel uneven areas.

Control of noxious weeds such as johnsongrass or bermudagrass is best accomplished the summer before planting the orchard. Preplant herbicides may be applied or incorporated during the winter before planting to reduce annual grass and broadleaf weed competition in the first growing season.

Tree spacing and planting

A square planting of 20-foot rows with trees 20 feet apart in the row is ideal for almost all plum varieties planted on most soil types, but even with this commercially accepted spacing, trees may eventually crowd and some shading of lower fruitwood will occur. Closer plantings provide increased production for the first 4 or 5 years, but difficulties in maintaining fruitwood can be expected later with many varieties. On very sandy soils, the spacing can be reduced to 18×20 feet or 18×18 feet. A few "spreading" type plum varieties produce well when planted 22×22 feet, or 24×24 feet on deep sandy loam soils.

Trees are often ordered in May and June during the nursery budding season the year before planting (these are called "June buds"). Yearling trees may also be planted. Common trunk-diameter size ranges from ⅜ inch to ⅝ inch. (Very large and very small trees usually grow slower and often require extra care.)

Trees should be "healed in" immediately after arrival from the nursery. This consists of digging a shallow trench and covering roots with moist soil to prevent drying. Trees should be planted in January or before February 15; if planted later their first-season growth may be reduced. If planting is delayed trees may be held in cold storage for planting as late as March or April. These trees will survive but the first year's growth will be less than that of earlier plantings.

Holes may be dug by shovel or auger. If wet soils are a problem, digging should be done in late fall or early winter prior to heavy rains. Planting holes should be just deep and wide enough to accommodate the root system in its natural position; if they are much deeper than the root system undesirable tree settling will occur. Roots should be trimmed slightly rather than curled around to fit the hole. Trees should be set in the hole at the same depth they grew in the nursery, with the rootstock scar at the bud union facing away from intense afternoon sun to reduce sunburn during the first growing season. Commercial fertilizers should not be placed in planting holes.

After planting, holes should be filled with pulverized soil and lightly irrigated to settle soil around roots and remove air pockets. Long soaking irrigations followed by periods of rain may damage root systems of newly planted trees.

Trees are normally headed back at planting time to knee height (22–24 inches), and large side-branches below this point should be removed or clipped back to one bud. Painting the trunk with white interior latex paint immediately after planting helps prevent sunburn and Western flat-headed borer damage. Cardboard tree wraps also protect tree trunks from damage.

Tree wraps and paint should not reach closer than 6 inches below the headed tree top.

Caring for young trees

Young plum trees should be given frequent light irrigations for the first year. Sandy soils will require more frequent irrigations than loam soils. At the onset of hot weather, irrigation frequency and amounts are increased. Root drowning can result from too much water early in the growing season.

Once trees are well established and shoot growth is 6 to 12 inches long, about one-eighth of a pound of actual nitrogen can be added to the furrow bottom close to each tree. This will assure adequate nitrogen for spring and summer growth. Care must be taken not to over-fertilize, as excessive amounts will cause injury.

Weeds compete for moisture and nutrients but can be eliminated by careful cultivation, hoeing, or chemical spraying. Rootstock suckers should be removed from the base of trees, taking care not to cause injuries which act as entry sites for disease organisms.

Frequent inspection for pests such as cutworms and mites is necessary. Early detection and control of harmful insects prevents serious tree damage.

Rabbits can be a serious problem in newly planted plum trees—they eat shoots and cause deformed growth which is difficult to prune and shape the first winter. Repellents are short lived and not completely satisfactory, so chicken-wire fences may be needed around young orchards.

Rootstocks

Plums do not come true from seed and consequently clones or varieties are propagated by budding on seedlings or cuttings in the nursery. Plums are grown mainly on plum rootstock, but peach rootstock is also widely used.

Myrobalan plum. Myrobalan plum seedlings and selected hardwood cuttings such as Myrobalan 29C are hardy, long-lived, and adaptable to a wide range of soil types and moisture conditions. Trees grown on this rootstock do not grow well when planted on extremely heavy soils, but they are tolerant of high-moisture conditions due to high rainfall or heavy irrigations. Myrobalan plum is compatible with most commercial plum varieties.

Myrobalan cuttings and seedlings are susceptible to oak root fungus, but are moderately resistant to crown rot. Myrobalan 29C cuttings are more resistant to crown gall than seedlings, but less resistant than Marianna 2624. They are less susceptible than peach to Verticillium wilt.

Myrobalan 29C is immune to both major species of root-knot nematodes (*Meloidogyne incognita* and *M. javanica*). Many Myrobalan seedlings are susceptible to both of these. Both seedlings and cuttings are susceptible to root-lesion nematode (*Pratylenchus vulnus).*

Marianna 2624. This selected strain of Marianna plum is propagated by hardwood cuttings, and like trees grown on Myrobalan 29C tends to be shallow rooted for the first 3 to 4 years due to lack of a tap root. It also has a tendency to sucker at the tree base and from cut roots. Marianna 2624 is well adapted to a wide range of soil and moisture conditions. It is commonly used as a rootstock where soils tend to be wet due to excessive irrigation or rain. Trees grown on this rootstock are smaller and less vigorous when grown on extremely heavy soils. Marianna 2624 is compatible with most commercial plum varieties.

Marianna 2624 is moderately resistant to oak root fungus, crown rot, and crown gall. It is less susceptible to Verticillium wilt than peach but highly susceptible to bacterial canker.

Marianna 2624 is immune to both species of root-knot nematodes but, like Myrobalan, is susceptible to root-lesion nematodes.

Peach. Peach seedlings are a major rootstock for plums in California. Trees grown on peach rootstock do best when grown on well-drained, sandy loam soils and are not tolerant of wet-soil conditions. Plums tend to produce earlier and set more consistently on peach rootstocks. Peach seedlings are compatible with most commercial plum varieties (although a large scion overgrowth may develop as the tree grows older).

Peach is susceptible to oak root fungus, crown rot, and crown gall. Plums on peach seedlings are generally less susceptible to bacterial canker than those on plum rootstocks.

Lovell peach seedlings are susceptible to both species of root-knot as well as root-lesion nematodes. Rancho Resistant and S-37 seedlings are resistant to only *M. incognita.*

Nemaguard is the most common peach rootstock used for plums. Seedlings are resistant to *M. javanica* and most are immune to *M. incognita.* Root-knot nematodes are not a problem in orchards planted on Nemaguard. The effect of root-lesion and other nematodes on Nemaguard rootstock is not known.

POLLENATION

Most European and Japanese commercial plum varieties grown in California require pollenizers to set satisfactory crops. Cross pollenation may be accomplished in several ways. Two varieties can be planted together in various row combinations, or individual pollenizer trees may be spaced throughout the orchard. Pollenizer limbs are sometimes grafted directly in trees to assure adequate pollenation.

There are many important factors involved in choosing the right combination of varieties to insure consistent set. These include inter-compatibility, time of bloom, commercial value of each variety, time of fruit maturity, number of pollenizer trees needed, area where grown, bee activity, closeness of pollenizer to variety to be pollenized, and efficiency of pollenizers.

Some varieties may receive too much pollen from a pollenizer; this results in excessive fruit set and high thinning costs. Slight underpollenation often minimizes thinning costs yet provides adequate crops of good sized fruit.

Variety characteristics

European plums. Commercial varieties of European plums grown in California fall into either one of two groups, self-fruitful or self-unfruitful. On the average, about 30 per cent of the flowers on the self-fruitful varieties will set whether the flowers have been crossed or self-pollenized. This is considered more than enough for a commercial set. In some years, bees may be necessary to assure set even with self-fruitful varieties. Varieties of the self-unfruitful group have flowers that set only about 1 to 2 per cent which is not sufficient for a commercial crop. These varieties (including President and Standard) must be interplanted with pollenizing varieties.

Japanese plums. Most commercial Japanese plum varieties grown in California are self-unfruitful and require cross-pollenation to produce commer-

cial crops. Several varieties, including Santa Rosa, Late Santa Rosa, Beauty, Redroy, and Nubiana are partially self-fruitful, but may bear heavier when planted among other varieties.

Self-fruitful or partly self-fruitful varieties may vary in their degree of self-fruitfulness from year to year and area to area. For example, Santa Rosa is considered self-fruitful in the Fresno-Tulare County area and usually produces well when planted in solid blocks. However, in some northern California counties, Santa Rosa requires cross-pollenation by bees from other varieties.

Varieties must bloom at about the same time and provide adequate pollen capable of setting fruit in order to be good pollenizers. Following a winter with adequate chilling, warm weather in February usually causes a relatively short bloom period but a good overlap of varieties. In this situation, favorable cross-pollenation and good sets usually occur unless the bloom period is extremely short and adverse weather occurs during this period. On the other hand, blossoming may be delayed after a mild winter and the bloom period greatly lengthened. Certain varieties may not cross-pollenate because their bloom is delayed too long to coincide with varieties having shorter chilling requirements.

A few Japanese plum varieties which produce large amounts of viable pollen are good pollenizers for many other varieties. These include Santa Rosa, Late Santa Rosa, Wickson, Laroda and Casselman. Myrobalan 5Q, a selected Myrobalan plum seedling with fruit of no commercial value, is a good pollenizer for most Japanese plum varieties. It is frequently used as a pollenizer limb grafted into trees throughout the orchard.

Varieties must bloom together to assure cross-pollenation. The bloom dates of the two varieties shown here do not overlap enough to insure consistent fruit sets.

Other varieties such as Burmosa, El Dorado, Red Beaut, and Kelsey are relatively poor pollenizers. Incompatibility along with deficient pollen production and non-viable pollen may be some of the reasons responsible. Under ideal winter chilling conditions and favorable weather during bloom, however, they may produce enough pollen to set other varieties.

Certain variety combinations such as Queen Ann and El Dorado are ineffective as pollenizers for each other even though they may be satisfactory pollenizers for other varieties. Some variety combinations, such as Laroda

POLLENIZERS FOR JAPANESE PLUM VARIETIES

Pollenizer

Variety to be pollinated	Ace	Beauty	Burmosa	Casselman	Duarte	El Dorado	Elephant Heart	Friar	Frontier	Grand Rosa	July Santa Rosa	Kelsey	Laroda	Late Santa Rosa	Mariposa	Myrobalan 5Q	Nubiana	Queen Ann	Queen Rosa	Red Beaut	Red Heart	Redroy	Roysum	Santa Rosa	Simka	Wickson
Ace	O	G												G										G		G
Beauty		F				G							G									G		F		G
Burmosa		P	O			P							F	G	G	G	F	F				P		G		F
Casselman				F																						
Duarte		G			O		G				G			G										G		G
El Dorado		G	P			O							G	F	F		P	P				F		F		G
Elephant Heart		F				P	O					P	P	F		G	P	P			G	P		F		P
Friar				G				O	F				G					P	G		G	G		G		
Frontier				G				G	O		G		G	G							G	G		G		G
Grand Rosa										O	G			G								G		G		
July Santa Rosa											F															
Kelsey		F				F						O				G										G
Laroda		G				P		G	G				O				G	G	G			P		G		F
Late Santa Rosa		G				P	G					P	F	F		F	P					P		F		G
Mariposa		F	F			P							F		O	G	F					F		F		
Nubiana		F				G	F						G	F		G	P					G		F		F
Queen Ann			P			P	G	P				P	G	G	P	G	P	O				G		G		F
Queen Rosa				G				G	F				G						O			G		G	G	
Red Beaut		F		F			F							F	F					O				F		F
Redroy		G				G						F	G	F		G	G	G				F		F		F
Roysum																							F			
Santa Rosa		G	F			F	G							F		F	F	F						F		G
Simka																									G	
Wickson		F										P												G		O

G = Good fruit set most years
F = Fair fruit set most years
P = Poor or no fruit set most years
O = Variety is self-unfruitful

and El Dorado are compatible in only one direction (Laroda pollen gives good sets on El Dorado, but El Dorado pollen fails to set Laroda). Thus in the case of each of the above examples, at least one more pollenizer must be added to set a crop.

Bees as pollen carriers

Honeybees are the most important insect used to carry pollen from flower to flower in plums. Wind and other insects cannot be relied upon to provide sufficient cross-pollenation where pollenator varieties are necessary. In

some orchards wild bees are present in sufficient numbers to assure good sets, but in most orchards containing varieties needing cross-pollenation honeybees must be placed at strategic locations throughout the orchard.

At least one to two hives per acre are necessary to provide sufficient cross-pollenation; the most effective pollenation occurs within a radius of 100 yards from the colonies. It is not always possible to place colonies to overlap at 100 yards, but a practical method is to scatter hives in groups of 5 to 10 on the orchard periphery. However, in larger orchards some colonies should be placed in the orchard itself.

Ideally, bees should be placed in the orchard when the flowers are beginning to open. Elimination of nearby blooming weeds and cover crops reduces competitive bloom. Weather plays an important role in bee flight and pollenation: bees are almost inactive below 55 or 60° F, and optimum temperatures are 65 to 80° F; rain during bloom will reduce bee activity but will not seriously reduce cross-pollenation unless accompanied by cold temperatures.

Pollenizer tree arrangements

When arranging pollenizer trees in orchards, the most common planting scheme is four inside rows of one variety alternating with four inside rows of another variety, each of which pollenizes the other, thusly:

```
+ + o o o o + + + + o o
+ + o o o o + + + + o o
+ + o o o o + + + + o o
+ + o o o o + + + + o o
+ + o o o o + + + + o o
+ + o o o o + + + + o o
```

This system facilitates orchard operations such as irrigation and harvest. Border rows have only two rows of one variety. Where one variety is favored, an arrangement of four inside rows of that variety alternating with two inside rows of another pollenator is commonly used.

```
o o + + o o o o + + o o
o o + + o o o o + + o o
o o + + o o o o + + o o
o o + + o o o o + + o o
o o + + o o o o + + o o
o o + + o o o o + + o o
```

This arrangement assures good pollenation, while allowing greater production of the favored variety. Ease of irrigation and harvest are still maintained.

Where a minimum of pollenizer trees is desired they should be placed in the orchard in an orderly fashion for picking and other operations. Arrangements for supplying pollen to the main variety while keeping the number of pollenizers to a minimum are common. Examples include placing one tree of the pollenizer to eight of the main variety, with each pollenizer placed every third tree in every third row. In this case, each tree of the main variety "sees" a pollenator tree.

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o o o o o o
o + o o + o
o o o o o o
o o o o o o
o + o o + o
o o o o o o
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In areas where certain variety combinations require heavy annual thinning, fewer pollenizers such as every fourth tree in every fourth row may be adequate.

Where necessary, pollenizers may be added after an orchard is established by grafting tree limbs. The number of trees with pollenizer limbs depends upon the density of pollen desired. When scattered throughout the orchard, pollenizer limbs may be pruned after bloom to allow the greatest number of flowers to remain during the blooming period. Fruit formed on pollenizer limbs can be knocked off

with poles, or thinned and picked if desired.

It is easy to establish pollenizer limbs in young trees. Grafted limbs are difficult to establish in older, large trees; consequently, in older orchards entire trees should be grafted to pollenizer varieties. Orchards requiring additional pollenizers may be helped by placing bouquets in trees. Containers of water with fresh opening branches of pollenizing bloom are placed in each tree. Bees must be present to assure that pollen is carried from bouquets to flowers requiring pollenization.

CULTIVATION

In the major plum-producing districts of California several systems of cultivation are used.

Complete cultivation. In this system, orchards are disced three to four times a year to control weeds. Where weather conditions permit, the orchard is disced and furrows or checks are made in late winter; this allows irrigation water to be run for frost protection in event of sub-freezing temperatures during or following bloom. The first cultivation may necessarily be delayed until after bloom in wet years. The orchard is disced again to incorporate weeds and smooth ground prior to thinning. Refurrowing takes place following thinning. Early-maturing varieties will not be disced again until after picking;

The relatively new system of semi-noncultivation has permanent herbicide-treated berms in the tree rows. Either cultivation (shown here) or grass mowing is used in the row middles.

later-maturing varieties may have another discing and furrowing or bordering before picking. Most orchards are disced and smoothed in the fall before winter rains begin.

Bare non-cultivation. A few plum orchards are under complete noncultivation. The entire orchard floor including two to three broad, flat furrows per middle are kept completely weed free. Weed oil or a pre-emergence herbicide or both are used to maintain a weed-free surface. Weed control is expensive the first year, but the advantages of no discing or furrowing plus low weed-control costs during subsequent years make this system attractive. Sealing of the soil surface causing poor water penetration has been a problem in some non-cultivated orchards. Fruit sunburning due to sun reflection from water in weed-free broad flat furrows has discouraged some growers from adopting completely bare non-cultivation for sensitive varieties.

Semi-non-cultivation. This system of orchard soil-management incorporates the good features of both previously described methods. Permanent berms, or borders, are formed in the tree row. They are rounded, about 6 inches high and 3 to 5 feet wide, and weeds are controlled on them with pre-emergence or contact herbicides. Middles may be maintained by occasional one-way discing and furrowing. More popular is a system in which the middles are flat and flood irrigated. Weeds or planted permanent cover crops such as self-seeding clovers are mowed rather than disced. Improved pest management, better water penetration, and winter access to the orchard for such operations as dormant spraying are benefits of this system. Prunings are shredded in the flat middles. Occasional weed mowing and a once-a-year pre-emergence herbicide application to berms may be the only soil-management operations necessary.

GRAFTING

Sometimes it is necessary to top-work (graft) plum trees from one variety to another. It may be desirable to graft to a new more promising plum or change peach or nectarines to plums. Varieties are also changed to add or reduce pollenizers.

Top-working established bearing trees results in a return to full production sooner than planting new trees, but tree age should be considered before top-working. Grafting will not extend the life of the orchard, and may shorten it in some instances. It is probably uneconomical to top-work an orchard after it reaches the age of 10 to 12 years. Generally speaking, only trees younger than 10 years should be grafted to change varieties.

Certain precautions must be considered before top-working an orchard. European varieties do not grow successfully when grafted on Japanese types, but many Japanese plums can be grafted successfully on most European types. Peach and nectarine trees make good stock for Japanese plums, but not all European plums grow successfully on these stocks. Plums should not be grafted to almond or apricot trees.

Some combinations of plums on peach or plum rootstock produce scion overgrowth. Although this may appear to be an incompatible combination, it does not mean the tree will not

Scions are placed in several limbs of each grafted tree. "Nurse" limbs are left until the grafts are growing well.

grow and produce satisfactorily.

Grafted orchards sometimes fail soon after grafting because of virus disorders contained in the stock or scion or both. Scions may turn yellow or orange in color and die soon after growth begins. This "virus shock" may result when a virus-free scion is placed into a stock containing a virus or virus complex, or vice versa.

Top-working is done in winter and early spring. Main branches are removed to about 6 to 12 inches above the crotch of the tree. If the tree is about 4 years or older, a "nurse" limb is left; no nurse limb is necessary on very young trees. Two to three scions are placed in each limb stub. The sawkerf graft is most common but cleft and bark grafts are also used. Follow up re-waxing, suckering, support protection from wind, and summer pruning are all important in making the top-worked orchard successful. Surplus scions are removed or severely cut back and trees pruned to new standards at the end of the first season's growth.

PRUNING

There are two pruning phases in the life of the tree: training and maintenance. A young tree is pruned (or trained) to provide structural strength and maximum fruiting area and fruitfulness at an early age. Mature bearing trees are pruned to provide for maintenance and renewal of fruit wood. Bearing potential is adjusted by the amount of fruit wood left.

Left: Unpruned 2-year-old tree before the second dormant pruning. Right: Secondary scaffolds have been thinned and spaced during pruning. Scaffold limbs are pruned to outside spreading branches, and no limbs are headed back. Note that some small lateral shoots were left to develop fruit wood.

Training the tree

In California, plum trees are pruned during their dormant season to an open-center system. The height of the tree crotch or point of primary scaffolds is determined by cutting back the tree at planting time. Normally, trees are headed back 22 to 24 inches above ground. Lower heading (18 to 20 inches) results in trees branching closer to the ground. Where a berm cultivation system is planned, trees should be headed high enough to allow for extra soil to be placed around the trunk.

Scaffold branches are selected during the first dormant pruning after one season's growth, and three or four of these are evenly distributed around the trunk. Primary branches should be spaced 6 to 8 inches apart along the trunk, but this is not always possible because most branches arise near the point of heading.

Most Japanese plums do not require topping or heading of the primaries during training because sufficient lateral branching occurs naturally. Since

plums usually have upright growth habits, it is important to remove inside branches and select those with greater spread. A few naturally spreading varieties, such as Burmosa, must be headed to promote secondary branching at desired points. Heading back and selection of upright branches reduces spreading. European plums must also be headed during the first dormant pruning to promote secondary branching.

Secondary branches are selected during the second, third, and fourth dormant seasons. At the end of 4 years of growth and pruning a tree should have three to four primary scaffolds at the crotch, with five to seven secondaries 3½ to 4½ feet above ground. Further secondary branching at 7 to 9 feet fills in the expanded area without crowding. Spaced secondary branching allows light to filter into the center of the tree and stimulate development of fruiting wood in that area.

Growers sometimes utilize summer pruning to select branches prior to the dormant season, thus promoting maximum growth in the desired branches. Undesired shoots such as inside branches or flat limbs are pinched back to suppress growth. Complete removal of these branches would result in loss of desired leaf surface and reduced total growth of the tree. Topping upright-growing plum varieties during May or early June for the first two growing seasons results in a more compact tree. Outside growing branches increase in vigor resulting in a more spreading type of growth.

Pruning mature trees

Pruning mature plum trees is important in providing and maintaining fruit wood and adjusting potential crop size while containing tree height and spread. Both Japanese and European plums bear most of their crop on lateral spurs which develop along larger branches. Spurs of Japanese plums are usually 2 to 4 inches long, while those on European plums are shorter. Many Japanese varieties will set some additional fruit on longer 1-year-old shoots. Annual dormant pruning involves thinning fruit wood throughout the tree to reduce crop load and encourage renewal growth for later fruiting. Interfering branches, broken limbs, and water sprouts are removed and cut smoothly back to other branches.

Once trees reach a desired height (often 11 to 14 feet) they are topped or cut back to the same point each year by hand shears or machine. It is desirable to remove lateral stubs at this point to eliminate "crows nests" which often result in excessive shading and loss of fruit wood.

Plum fruiting spurs live for 5 to 8 years. While it is necessary to prune for renewal of some spurs each season, most new growth is removed. This eliminates over-bearing and reduces fruit thinning costs. It may be necessary to remove 75 to 85 per cent of the new growth within a mature tree.

European plums usually require less fruit thinning; therefore, fewer larger pruning cuts will provide adequate fruit-wood thinning.

Excessive pruning results in heavy vegetative growth with low fruitfulness, but insufficient pruning results in excessive fruiting followed by little new fruit-wood development and (finally) small crops. Observant growers adjust the severity of pruning each variety according to the previous year's crop and top growth. Orchards with less than 2 to 4 feet of top growth per season are pruned more severely. Those with 6 to 8 feet growth should be pruned lightly, thus leaving more fruiting area for the next season. Nitrogen fertilization and irrigation also influence top growth and must be considered when using this pruning guide.

FROST PROTECTION

Because most plum-growing districts in California are subject to below freezing temperatures at bloom, frost protection is important.

The temperature at which flowers are damaged depends upon the stage of bloom and duration of freeze. When buds are still closed but showing color, they can withstand 25° F for 30 minutes or less without damage. At full bloom, flowers can withstand 28° F for 30 minutes, but small green fruits can only endure 30° F for the same period.

Most freezing nights during plum bloom are the result of temperature-inversion conditions. Freshly cultivated orchards or those with cover crops accumulate less heat during the day and lose heat faster at night, thus colder temperatures result. Smooth, bare, moist soils maintain higher orchard temperatures during radiation frosts.

Some growers commonly border or furrow their orchard following discing just prior to bloom. This is followed by an irrigation to smooth the middles or furrows in case it becomes necessary to run additional irrigation water during cold nights. Well water, with temperatures usually far above freezing, provides heat and slows temperature fall. Heat given off from running water often maintains temperatures 1 to 3 degrees higher than temperatures in dry orchards.

FRUIT THINNING

Plums often set more fruit than can be raised to desirable or marketable size. When part of the crop is removed by thinning, the remaining fruit receives a greater share of food manufactured by leaves. Thus, the greater the leaf surface per fruit the larger the final fruit size. Thinning also allows removal of undesirable fruits and reduces limb breakage. Although thinning reduces total crop, it usually increases salable tonnage.

At least four types of thinning are used: hand labor, mechanical shakers, chemical thinning, and poles. Currently, hand labor is most widely used although other systems are being improved and may prove feasible in the near future. (For example, use of mechanical shakers to reduce the crop followed by selective, touch-up hand thinning looks promising.)

In hand thinning, workers pull, pinch, or strip undesirable fruit from trees by hand. Remaining fruit is spaced along branches with one to two fruits per spur. Excessive fruiting branches result in excessive fruits and high thinning costs. By removing varying amounts of fruit wood at pruning time on heavy setting varieties the amount of thinning necessary in the spring can be reduced.

Well-planned thinning is essential

Proper thinning time is vital for optimum crop development at lowest cost. Thinning too early can prove risky because hail, frost, or "June-drop" may further reduce the marketable crop. Labor costs are usually higher with early thinning, but late thinning often results in only partial increase in fruit size.

Following rapid early growth, fruit growth slows as the pit begins to harden. Growers commonly begin thinning just before and continue through this pit-hardening period. (Thinning after the pit has hardened does not produce maximum size fruit.) Thinning often begins in early April and continues into May in the San Joaquin Valley. Varietal characteristics such as time of maturity and fruit sizing capability are other important factors in determining thinning time.

The amount of fruit to leave on trees is determined best by past experience with a specific orchard using previous production records as guidelines. Many growers use an "estimate and count" technique to determine the number of fruits to leave on trees. Counting fruit on one scaffold and multiplying by the number of scaffolds per tree can be fairly accurate for determining the number of plums remaining after thinning. Even where follow-up spot counting is not used, growers must use lessons from past experience in closely supervising thinning crews. The key factor to successful thinning is continual counting, evaluation, and adjustments during thinning.

More fruit can be sized and matured in the top half of the tree; therefore, more fruit should be produced there. Although hail scars and other defects can be removed, growers cannot afford complete inspection of each fruit by thinners, so some compromise must be reached to stay within economic bounds.

Even with well-supervised thinning, it may be necessary to use poles to touch up clusters and missed limbs a week or two later.

IRRIGATION

Plums grown in California must be irrigated to be commercially profitable. The time, frequency, and amount of irrigation water depends upon the variety of trees, location, soil type, and topography.

Plums grown in foothills are generally irrigated with sprinklers. Water application on hillside orchards is difficult because of uneveness of slopes and erosion, but properly engineered sprinkler systems can apply water to them at a rate equal to or less than the intake capacity of the soil and thereby eliminate run-off.

Plums grown on valley floors are on relatively flat lands where furrow, flood, or middle-flooding methods of irrigation are used. The system used is not nearly so important as is supplying the tree with enough water to produce a good crop and adequate new growth.

In general, plums require readily available moisture through harvest with decreasing amounts for the balance of the season. In areas where water is plentiful, which includes most of the major plum-growing districts, irrigation efficiency is not of major concern to growers. This is particularly true where trees are grown on Myrobalan or Marianna 2624 rootstocks which tolerate occasional over-irrigation. Plums grown on peach rootstock must be irrigated more carefully because of greater susceptibility to wet-soil problems such as crown rot.

Each irrigation should supply enough water to fill soil in the root

zone to field capacity. The time length of water application will vary from 1 to 2 hours to fill a check to 72 hours for furrows in clay soils. Irrigation frequency may vary from once per week to only two to three times during the growing season, depending on soil type and climate. Most orchards use at least 36-acre-inches per year, but some use 48 to 54 acre-inches annually.

Trees must have adequate amounts of water available throughout the growing season to properly size fruit, and to provide sufficient new growth and flower-bud formation. Frequent inspections of soil moisture should be made by digging into the root zone with a shovel, soil tube, or auger. Soil-moisture measuring devices such as tensiometers or gypsum blocks may also be helpful in determining how rapidly water is being depleted from the soil, and when the next irrigation should be applied.

In plum orchards where there are abrupt changes, such as sand streaks, it is important to watch soil-moisture depletion in areas tending to dry out first. Sand streaks have a lower water-holding capacity than the rest of the orchard, and these areas must be irrigated frequently during the summer. Where furrow or flood irrigation is used, irrigations must be based upon the section that dries out first. It takes a keen observer to properly irrigate orchards containing abrupt soil changes.

Young trees are particularly sensitive to proper irrigation—they have a limited root system in a small volume of soil and the root zone can become dry even though surrounding soil is moist. One should check soil moisture at the base of the tree where roots are active. Frequent light irrigations are best for young trees. If soil around young tree roots is allowed to dry for a short period between irrigations, growth may stop and there will be erratic growth flushes and less total growth for the season.

It is a temptation to reduce irrigation to a minimum after harvest. Although it is not essential to maintain high soil moisture after harvest, irrigations must continue. Flower-bud development, nutrient uptake, and subsequent crop development are dependent on favorable soil moisture the year round. Adequate post-harvest irrigations play a big part in this relationship.

Over-irrigation can also be harmful to trees—this often occurs with heavy clay soils. Irrigation frequency and water quantity must be carefully balanced not to saturate the soil for long periods of time. Soil ripping sometimes helps where hardpan causes soil saturation in the top few feet of soil, and re-leveling sometimes helps overcome low spots where water may pond. Drain ditches and tail-water return systems reduce excess water accumulation and tree drowning at the lower end of irrigation runs.

IMPROVING WATER PENETRATION OF SOIL

Poor water penetration due to plow pan conditions is common in plum orchards. Soil becomes so compacted because of constant heavy traffic with tractors and other equipment that water may penetrate only a few inches into the furrow bottoms by early or mid-summer, even after irrigations of 1 to 3 days. To overcome this, many orchards are chiseled to a depth of 18 to 20 inches in the fall. Growers make one round per middle pulling two

shanks, one of which is under a furrow bottom; this breaks up the plow pan and allows for deep water penetration. Chiseling in late fall to within 4 to 5 feet of the tree will not damage roots severely enough to adversely affect next year's crop. Cross chiseling also helps improve water penetration. Breaking the plow pan by chiseling provides short-term improvement in water penetration but does not eliminate the basic cause of soil compaction.

Cover crops for increased penetration

Winter cover crops are sometimes planted in California plum orchards to improve water penetration. (They are not used as "green manure" crops.) Roots from cover crops penetrate the compacted layer of soil and open channels for water to reach deeper into the soil. Winter weed growth may be as beneficial as planting a specific cover crop. Barley, barley-vetch combination, vetch, cereal rye, and horse beans are sometimes planted as cover crops. Generally, cereals are more beneficial in reducing water-penetration problems. Barley is most commonly used and is broadcast or drilled at the rate of about 40 pounds of seed per acre. Cereal rye grows well during cooler temperatures and is sometimes preferred. At least 40 pounds of nitrogen per acre should be provided at planting time to insure good growth.

There are disadvantages to cover crops, however, and these frequently outweigh their usefulness in improving soil structure. Working in wet, dense cover crops is difficult and uncomfortable for pruners. Cover crops make the orchard colder during bloom, thus increasing the possibility of frost damage.

Permanent year-round cover crops help prevent soil compaction problems (see page 14). These are usually mowed, even in winter or early spring, thus eliminating some disadvantages of planted annual cover crops.

Annual summer cover crops are usually impractical and unnecessary because normal orchard operations and shade interfere with their growth.

INTERCROPPING YOUNG TREES

Intercropping (planting annual summer crops such as cotton, vegetables, or beans in the middle of tree rows) is frequently practiced in young plum orchards, although growers are divided in their opinions of its usefulness. Some young orchards thrive despite annual intercrops between tree rows, but others suffer reduced growth due to competition. Where intercropping is successful, precautions are taken to provide the young trees with adequate irrigation, fertilizer, weed control, and pest protection. Weed control with cultivation and summer spraying for insect pests may be difficult because the intercrop interferes with access to the trees. Another difficulty is that pesticides may not be registered for both the trees and the intercrop. Growers are sometimes reluctant to irrigate prior to harvesting the intercrop, and thus trees may suffer from lack of moisture.

In most cases it is probably best not to intercrop young plum trees, because of the risk of reduced tree-growth. However, if potential cash returns from the intercrop are great, the risk may be justified.

Increased production early in the life of the plum orchard is accomplished by double-setting plum trees in the row. As an example, the initial orchard setting distance is 20-foot rows with trees 10 feet apart in the row. After a few years, interset trees are removed for a permanent 20 × 20-foot spacing. This system is seldom successful because trees grow rapidly and soon interfere with proper training of the permanent trees. The extra cost of trees, training, cultural costs and removal exceed additional income from the interset tree, which may remain only 5 or 6 years.

FERTILIZATION

Leaf Analysis

Leaf analysis often provides information for determining deficiencies and excesses of important chemicals necessary for good production and growth. Proper timing of sampling is a vital part of leaf analysis—leaves should be collected from mid-June through July from non-fruiting spurs. Results of a leaf analysis along with observed growth and production responses provide a basic guide for orchard nutrition. Where weak spots exist in an orchard, separate samples should be collected for comparison.

Optimum Nutrient Levels of Japanese Plums
(leaf samples collected in July)

Nitrogen	2.3 – 2.8 per cent
Phosphorus	0.1 – 0.3 per cent
Potassium	> 1.0 per cent
Copper	4 ppm
Manganese	20 ppm
Chlorine	< 0.3 per cent
Sodium	< 0.2 per cent
Boron	30–60 ppm
Zinc	> 15 ppm
Calcium	> 1.0 per cent
Magnesium	0.25 per cent

A nutrition program for plums is similar to those for other deciduous fruit trees grown in California. Plums require adequate amounts of all major elements including nitrogen, phosphorus, potassium, magnesium, calcium, and sulfur, and micro-elements including zinc, manganese, iron, boron, and copper. With the exception of nitrogen, zinc, and iron, all these essential elements are usually abundantly available to plum trees in most California soils.

Profitable plum orchard fertilization depends upon recognizing certain deficiencies revealed by leaf and growth patterns, fruit symptoms, and leaf analysis.

Applying nitrogen

Nitrogen (N) is essential in almost all plum-orchard fertilizer programs. Trees lacking N are pale green with small leaves, stunted terminal growth, small fruit, and they exhibit early-fall coloration and loss of foliage.

Mature plum orchards require about 100 pounds of N per acre per year. On heavy soils, N is applied in fall or winter; on lighter, sandy loam soils, N is applied during winter so that it is taken into the ground by rain or irrigation water and made available to roots by bloom time. Early-maturing varieties should be fertilized in fall or early winter to prevent delayed fruit maturity due to excessive N available to the tree at harvest time. Excess N may cause delayed ripening, poor fruit color, and inferior quality. Later-

maturing, particularly heavy-bearing plum varieties on sandy loam or loam soils, may require more N to produce a large and good-sized crop. On light-textured sandy soils split applications of N, one in winter and another in May, for a total of 100 to 200 pounds of N per acre may be needed to assure an adequate supply for the entire growing season.

There are several forms of N available which show little or no difference in tree response so long as an adequate amount is applied. In some orchards, certain conditions may dictate a preference for a particular form of N because of soil acidity and water-penetration problems. Some forms readily leach out of the root zone, while others may cause unfavorable reactions on the soil's physical condition. Ease and cost of application are other factors to consider.

Plums absorb little nitrogen from foliage sprays; consequently, this method is not recommended to supply the tree's N requirement.

Applying zinc

Zinc is the micro-element most commonly found deficient throughout all plum-growing regions. The most obvious deficiency symptom consists of small, narrow, yellowish leaves bunched together, usually in the upper half of the tree—this is called "little leaf." Trees are stunted and produce no fruit if symptoms are severe.

The zinc deficient limb on the right has shortened rosette-like shoot growth and chlorotic, dwarfed leaves. The limb on the left was treated and normal growth occurred.

Zinc deficiency in plums is most easily corrected during the dormant season with a spray of 5 to 10 pounds zinc sulfate (36 per cent metallic zinc) per 100 gallons water. Zinc sulfate cannot be combined with oil sprays and must be applied alone, preferably at least 2 weeks prior to a dormant oil spray. Minor deficiencies requiring maintenance dosages of zinc are usually corrected by adding basic zinc sulfate to the regular dormant spray.

If symptoms appear in early spring, a spray of 5 pounds zinc oxide or 3 to 4 pounds basic zinc sulfate per 100 gallons water is applied. This spray will not correct symptoms on existing leaves, but will result in normal new growth. If it rains within a few days after application, leaf shot-holing and defoliation may occur, especially on such varieties as Santa Rosa. In zinc deficient orchards zinc sprays must be applied every year to keep symptoms from reappearing. Heavy applications of manure in such orchards will increase zinc-deficiency symptoms.

Iron deficiency

Iron deficiency, commonly known as "iron chlorosis" or "lime-induced chlorosis," is a serious problem in many plum orchards. Two frequent causes are alkali or other salts in the soil, and poorly aerated wet soils (particularly where peach rootstock is used). Orchards on calcareous or lime subsoils also have iron chlorosis. Occasionally, older weak trees become chlorotic due to deteriorated conductive systems.

Iron deficient leaves turn yellow between veins, which remain green. Later the entire leaf turns light yellow and eventually almost white in color. New growth is stunted with marginal leaf burn associated with severe cases.

Correcting iron cholorsis is difficult. Some orchards show mild symptoms each summer when heavily irrigated before harvest. Following harvest, when less water is applied, new growth is normal. Applications of soil sulfur (25 to 50 pounds per tree) correct iron chlorosis in some orchards, where high pH is a problem. Soil applications of iron chelates also may help. Costs of correction are usually high and may not justify treatment. Foliage sprays of iron are usually not effective.

Less common deficiencies

Potassium. There are several scattered reports of potassium deficiency in a number of California fruit and nut crops. It is more commonly reported in prunes than in plums because of their heavy-bearing habits. Deficiency symptoms appear as a leaf scorch on both Japanese and European plum types. For correction on about all but the most sandy soil 25 pounds potassium sulfate per tree are necessary, although rates as low as 10 pounds per tree have been found adequate on acid foothill soils.

Manganese. Manganese deficiency is occasionally seen in California plum orchards and is often associated with alkali soils because alkalinity reduces manganese availability to the tree. The midrib and main veins of leaves and adjacent leaf tissue remain green while leaf edges are chlorotic. Correction can be at least partially obtained on alkali soils by lowering the soil pH. However, correction is seldom necessary. During cool moist springs, symptoms often appear briefly but disappear in warmer weather.

Boron. Boron deficiency symptoms are infrequently seen in European plums in California. Fruit exhibits brown sunken areas in the flesh; this can be corrected with a spray or soil application of boron compounds. No

leaf or shoot injury is associated with this deficiency in European plums. (Problems of excess boron have been encountered, mostly in European varieties. Symptoms include terminal shoot dieback, gumming, witches broom effect, swollen nodes, and swollen areas on leaf ribs.)

Phosphorus. Plums in California have not responded to applications of phosphorus. Unlike field or vegetable crops which frequently become deficient in phosphorus, fruit trees seem to get enough from the soil even when soil tests show low phosphorus availability.

Magnesium. Magnesium deficiency is rarely found in western orchards and is not a serious problem on plums grown in California.

PEST AND DISEASE CONTROL

Pest and disease problems are of continual concern to plum producers. Some of the major problems are briefly described here, but specific control recommendations are not included because they change frequently. Successful control measures require a knowledge of life cycles, application techniques, cultural techniques, and proper use of pesticides.

Integrated pest control. Indiscriminate use of pesticides can result in pest resistance, or outbreaks of other pests, or both. Successful growers depend on integrated pest-control programs which combine the use of beneficial insects and mites, pesticides which are least harmful to beneficials, accurate pesticide timing and application, some tolerance of insect injury, and cultural techniques which reduce pest problems. Such programs offer great potential for eliminating serious pest outbreaks and reducing pesticide applications. However, this requires a knowledge of pest and disease cycles plus constant monitoring within the orchard.

Pesticide applications. Until recently most applications were made with dilute sprayers, but low-volume sprayers are now being used also. Low-volume applications have certain advantages such as reduced pesticide costs and less costly equipment. Both systems should be studied before deciding what equipment to use in any specific situation.

DISEASES

Bacterial canker (bacterial gummosis). This disease is associated with a parasitic bacterium, *Pseudomonas syringae*, although the host-pathogen relationship is not fully understood. Because of fall, winter, and early spring activity of the bacterium, infected trees become cholorotic, wilted, or fail to leaf out properly in the spring. Further inspection by cutting into diseased limbs usually reveals dark, sour-smelling cankers. The cankers sometimes girdle limbs or entire tree trunks and cause death of the tree parts above the girdle. Young trees between the ages of 2 to 8 years are most

affected. The disease is distinguished from root drowning by the fact that bacterial canker does not affect the tree below ground and prolific suckering from the crown area is common. It is most frequently, but not always, associated with sandy soils.

When rains and low temperatures continue through the blossom and leafing-out period, *P. syringae* may attack young plum leaves and flowers, resulting in leaf shot hole plus blossom and leaf blast. This phase of the disease is known as bacterial blast.

There is no completely satisfactory control program, but Bordeaux sprays at leaf fall may give partial control. Delaying pruning until late winter may also help. To date, preplant fumigation followed by annual postplant treatments have provided more protection than any other practice although no single treatment has consistently and completely eliminated the problem. Trees planted on peach rootstock (especially Lovell) tend to survive longer than those planted on plum rootstock.

Crown gall. This disease, caused by the bacterial pathogen, *Agrobacterium tumefaciens,* affects the crown and roots of plum trees and causes rough, disoriented gall growth. The disease is often introduced into the orchard on nursery trees which should be carefully inspected on arrival from the nursery. Trees with galls should be discarded, and if a high percentage of trees exhibit the disorder the entire lot should be refused.

In the orchard, galls often originate where tree trunks have been injured by implements (cutting suckers or hoeing weeds often causes injuries in which the disease gains a foothold). Chemical compounds which kill small galls when painted on the affected area are available but larger galls must be removed before the affected area is treated.

Oak root fungus. Oak root fungus is caused by the fungus *Armillaria mellea* which exists in old, diseased roots. The fungus may lie dormant in old roots in the soil for many years before infecting plum tree roots growing into contact with it.

The disease often affects one or more trees and spreads in a circular pattern in the orchard. Oak root fungus affected trees weaken and lose color because of trunk-girdling and death of the root system. Diseased trees usually die in early to mid-summer, although collapse can occur any time. The crown and roots of infected trees exhibit white fan-shaped mycelial growth between the wood and bark although the bark exterior may appear normal.

Soil fumigation is recommended for control but very rigid steps must be followed to obtain satisfactory results. Marianna 2624 shows more resistance than other rootstocks but still can be severely injured or killed by the disease.

Brown rot. Fruit brown rot due to the fungus, *Monolinia fructicola,* has become an increasing problem with the development and planting of late-maturing plum varieties. (Blossom blight caused by *Monolinia laxa* is an occasional problem on Santa Rosa and Wickson varieties in northern California.) The disease becomes active as fruit begins to ripen and first shows as brown spots on the fruit surface. As the rot progresses, greyish spore masses are evident on the older rotted tissue.

Pre-harvest sprays followed by post-harvest treatments are recommended for those orchards and varieties with a brown rot problem in the San Joaquin Valley. Spring blossom sprays may also be necessary for highly susceptible varieties.

Crown rot. Crown rot (collar rot) is mainly a disease of young trees. It is

Virus disorders such as line pattern shown here often cause irregular leaf patterns.

caused by various species of the fungus *Phytophthora* which attack young trees during extended periods of high soil moisture and moderate temperature. Cankers occur in the bark below ground and may extend up along the trunk. The fungus is active in fall and spring, causing infected trees to appear pale after leafing. If cankers girdle the trunk, the tree will eventually die.

To reduce or prevent crown rot, trees should be planted at the same depth at which they grew in the nursery, or even higher. Excessive moisture should never be allowed to accumulate in or on the soil around the base of the tree. In heavier type soils plum rootstock is preferred over peach because of its greater crown rot resistance.

Cystospora canker. European plum varieties such as President and Standard are attacked by the fungus *Cytospora leucostoma.* Japanese plums are resistant. This fungus most frequently affects limb areas weakened by sunburn, overcropping, and scale insects. Cankers develop in the bark along main scaffolds, resulting in girdling and sudden collapse. Unlike other canker diseases of plum Cytospora canker is active in summer months.

Pruning to leave inside wood is an important control measure to protect main scaffolds from sunburn. Tree roping and mechanical topping also prevent trees from spreading excessively because of heavy crops. Nearby sources of shot-hole borers (which are thought to spread the disease) should be eliminated. Good cultural practices such as adequate fertilization, irrigation and scale insect control are important in preventing Cytospora canker.

Virus disorders. Many plum clones are affected by virus disorders such as ring spot, line pattern, and prune dwarf. Viruses reduce plant growth, crop production, and also interfere with grafting success. Trees affected by viruses cannot be cured, but these disorders can be prevented by using virus-free propagation material and certified virus-free trees.

INSECTS AND MITES

San Jose scale, *Quadraspidiotus perniciosus* (Comst.). This serious pest of plums causes economic losses every year. The adults, which feed on limbs, twigs and fruit, are small, circular, and gray. If the shell-like cover

is removed, a bright yellow female body is exposed. Young scale crawlers emerge from beneath the shell and move to fruit where they cause spotting. The insects have been known to seriously weaken fruiting branches and main scaffold limbs, thus causing permanent injury to mature trees. Injured limbs will ooze gum, and will exhibit rough bark and dieback. Dead leaves adhering to fruit spurs during the dormant season indicate presence of a scale problem.

Insecticide treatments are usually applied during the dormant season or during the spring crawler hatch in early May.

At one time olive scale (parlatoria scale), *Parlatoria oleae* (Colvée), was also a serious pest of plums, but beneficial insects have effectively reduced parlatoria scale populations to the point where it is uncommon to spray for this insect.

Dormant treatments or early spring treatments are used for control where control is necessary. The crawler hatch usually begins in late April in the San Joaquin Valley, and crawlers may later move to fruit and cause spotting.

Peach twig borer, *Anarsia lineatella* Zeller. A common worm pest, the borer attacks plum fruits and twig terminals. Terminal shoot die-back (strikes) are usually not as common in plums as in peaches or almonds. The mature larva is chocolate-brown with light-colored bands at the abdominal segments. Larvae usually attack ripening fruits near the stem and feed near the fruit surface. Varieties ripening during worm hatches require utmost protection since ripening fruits are most vulnerable.

Egg-hatch dates vary with the season but normally one brood occurs in mid-May and another in early July. Properly timed sprays can control the insect at these times.

Dead leaves sticking to fruit spurs in the winter indicate presence of San Jose scale.

Control most frequently is accomplished with a dormant spray which kills first instar larvae. These larvae overwinter in the bark at the crotches of last season's growth. An additional treatment may be necessary during the May brood, or upon appearance of excessive numbers of larvae later in the season.

Codling moth. The codling moth, *Laspeyresia pomonella,* (Linn) has become an increasing problem for plum producers in the southern San Joaquin Valley area. The insect, which is also a major pest in walnuts and apples, has become adapted to plums and can be found over an increasingly large area. Larvae (which are white with black heads) enter both immature and mature fruit and tunnel deeply into the fruit tissue. Frass is evident at the entry holes.

Adult moths emerge in early spring to lay eggs and can then be trapped to determine flight patterns, knowledge of which will determine spray timing. Until more is known about this pest on plums, local authorities should be consulted for current recommendations and trapping methods.

Codling moth larvae damage immature plums by internal feeding. Presence of larvae is most commonly indicated by entry holes in fruit.

Mites. Two-spotted mite, *Tetranychus urticae* Koch, and the Pacific mite, *T. pacificus* (McG.), attack plums during the summer. These "summer mites" feed on leaves, and when present in large numbers can cause leaf browning and defoliation.

Mature females of both groups are greenish to yellowish in color with a large, dark spot on each side of the body; they can usually be found on undersides of leaves. Both groups are known as "web-spinning" mites.

Because multiplication of these pests occurs so rapidly, their population levels should be closely watched so as to note any increases. Control measures using acaracides should be timed to halt population growth before serious leaf injury occurs—dormant spray treatments are not effective against these pests. Beneficial mite predators frequently control mite populations thus reducing the need for chemical treatments.

Infestations of European red mite, *Panonychus ulmi* (Koch), are not as common as two-spot and Pacific mite on Japanese plums although problems do occasionally arise on European plums. Adults are red to dark-red and they feed on leaves, thus giving trees a general light-green or yellow-green appearance. In contrast to other mites, the European red mite can be found on the upper leaf surface. It also overwinters in the egg form on the lower surface of branches.

Dormant applications for scale and peach twig borer are usually sufficiently effective on European red mite to hold populations in check, but foliar

acaracide applications are sometimes necessary.

Other insects and nematodes

Other insects which ocasionally are economic problems on plums include: the fruit tree leafroller, *Archips argyrospilus* (Walker); the leaf curl plum aphid, *Aphis helichrysi* Kalt.; the mealy plum aphid, *Hyalopterus pruni* (Geoffroy); western flower thrips, *Frankliniella occidentalis* (Perg.); and the red-humped caterpillar, *Schizura concinna* (J. E. Smith). Specific problems with these insects may require insecticide applications or integrated control programs.

Nematodes are small worm-like animals which attack roots. Their feeding causes physical damage to the root system which results in reduced tree growth. Three groups of nematodes are known to attack plums: *Meloidogyne* sp. (root knot nematodes), *Pratylenchus* sp. (lesion nematodes), and *Criconemoides* sp. (ring nematodes).

Proper rootstock selection can aid in reducing the damage caused by nematodes. Marianna 2624, Myrobalan 29C and Nemaguard are immune or resistant to the root knot nematodes (*Meloidogyne* sp.). However, none of the rootstocks presently available are known to be resistant to either the lesion nematode or the ring nematode. Commonly, preplant soil fumigation will overcome the effects of a mixed nematode population.

The effects of other nematodes such as *Xiphinema* sp. (dagger nematode) on plum production are not fully known. There is some evidence that postplant soil fumigation will lower populations of these nematodes and thus improve tree growth.

HARVESTING

The ripening fruit

A plum is considered mature when it has reached a point where it can continue its ripening process off the tree to completion with "good quality" for the consumer. Although mature fruit may not be "eating ripe" at harvest, it can attain desirable quality following a postharvest ripening period. The selected harvest maturity for each variety will depend on the intended market: for example, plums shipped to eastern markets are harvested at a less mature stage than those sold in local markets. Maturity standards for all plum varieties are established by marketing order groups and state regulations which cover the range from minimum to maximum maturity, thus insuring shipment of high-quality fruit while maintaining flexibility for specific markets.

Plums grown for long-distance shipment are picked when firm-ripe; at this stage they can be handled, packed, and shipped with less injury than when they are more mature. This also enables wholesale buyers and produce managers to move fruit through marketing channels with minimum losses. California plum growers and shippers must, therefore, furnish the intended market with good quality mature fruit while allowing for maximum storage and shelf life.

Plum fruits undergo color changes shortly before harvest. Japanese varieties change from green to light yellowish-green, then to a gradually developing yellow or straw color and, finally, they turn yellow or red. Mini-

mum maturity standards are based on these color changes. For example, the minimum maturity standard for Santa Rosa is "40 per cent of surface red color, or full light-greenish yellow" and for Red Beaut "¾ of surface distinct red or full light-greenish yellow." Some plums change from green to greenish blue or reddish purple and then to dark purple. Queen Ann maturity requirements, for example, are "good 'spring' full dark purple, or 90 per cent of surface dark purple color with remainder light greenish-yellow."

Although color changes are the most important single standard for maturity, other tests have been used to judge ripeness. These include fruit firmness and soluble solids which can be related to maturity. However, they are not always a reliable or practical means by which to regulate picking, sorting, and packing.

Picking and handling

Fruit ripens first at the tops of trees and later at the bottoms. This usually necessitates more than one picking, but because of the added expense it is desirable to keep pickings to a minimum. For varieties that tend to ripen uniformly, only one or two pickings are necessary; others require three or four. Market conditions, fruit quality, eveness of maturity, and weather and labor costs all enter into the picking pattern. The tendency is to rush picking on early maturing varieties where good market demand and prices reward those growers who are first on the market. When the price levels out on mid- or late-season varieties, picking may be delayed to allow the greatest volume to be handled in one or two pickings.

Plums are very perishable and must

Pickers carefully place plums in bins for transport to packing houses. Dropping or rough handling at this stage will greatly increase cullage.

be picked and handled with care. They are picked by hand into buckets with padded bottom liners. Where possible, stems are allowed to remain attached to the fruit. Precautions are taken not to puncture the fruit with fingernails, fruiting spurs or bucket edges. Pickers pour fruit from picking buckets into bins slowly and carefully, with minimum drop. The same precautions are used for picking boxes to insure that crushing or bruising does not occur from over-filling. Both bins and pick boxes should be placed in shade or covered to prevent fruit damage resulting from direct exposure to the sun.

Picked fruit must be removed from the orchard and hauled to the packinghouse as soon as possible. Caution is needed to reduce fruit bruising when handling boxes or bins within the orchard, in transit, and during unloading at the packing shed.

PACKING AND COOLING

Most plums are packed and shipped from central packinghouses located in plum-growing areas. These packinghouses often pack from 100 to 1200 or or more containers per hour. Each house may have several growers delivering fruit for packaging. The identity of each grower's fruit is maintained throughout the packing operation to obtain size and grade pack-out records. Packinghouses charge set fees per packed container for packing, cooling and selling. Some growers, however, prefer to operate on-the-farm or "shade tree" packing operations. Packing in the orchard or on the farm may be an advantage to the grower who can save expenses by doing it himself utilizing family labor. Growers packing under these circumstances handle a limited volume of fruit and often concentrate on special market outlets that desire riper fruit. Most on-the-farm packers market their fruit in California.

Whether fruit is packed on the farm or in a central packinghouse it is subject to industrywide size, grade, and package regulations which are set forth in the Agricultural Code of California. In addition the Plum Commodity Committee of the California Tree Fruit Agreement has established further regulations on fresh plums. The Federal Marketing Order program was estabilshed by growers and grower-shippers under supervision of the United States Department of Agriculture. Usually, the marketing order board (which is made up of plum producers) sets size and grade regulations that are stricter than state-established minimum standards. Federal-State inspectors strictly enforce these regulations, which are designed to establish and maintain an even flow of good quality plums into both intra- and interstate channels.

Modern commercial packinghouses are highly mechanized and handle fruit in a succession of steps. Bins or boxes of fruit arriving at a packinghouse may be packed immediately or precooled in forced air or hydrocooled before packing. The packing process begins as plums are removed from bins by automatic dumpers. Undersized fruit is removed by a drop-roll sizer before grading starts. Sorters carefully inspect each plum and remove defective fruit as it passes before them on moving belts. Some packing lines contain facilties for applying fungicides for disease control at this point in the

packing line. Next, automatic sizers rapidly size and distribute plums to packing lines where they are packed by hand or placed automatically into containers.

Three types of containers are used by the plum industry. These are the standard four-basket crate, the tight-fill box and the Los Angeles (L.A.) lug. Standard 4-basket crates are 4 to 5 inches deep. Each crate contains four baskets which hold two layers of fruit; a third layer tops the entire crate. Each packed crate contains 112 to 340 plums, depending upon fruit size. The tight fill container is usually a fiberboard, telescope carton. Unlike the hand-packing necessary for 4-basket crates, tight-fill containers are mechanically filled, settled by vibrating with top pressure, and then sealed. The L.A. lug is used for a "loose fill" pack. It is randomly filled with a bulge of fruit on top and a lid compressed over the bulge provides some top pressure to hold the fruit in place. Despite this, some settling often occurs in transit, and thus loose-fill packages are more subject to transit injury than are tight fill units. Some large plums are packed in molded plastic trays placed two layers deep in lugs, similar to the common peach and nectarine pack.

Each container is marked on the outside with a brand name, name and address of the packer, variety, weight (volume-fill containers only), and fruit size. Size designation for California plums is based upon the packing pattern found in the top layer in the standard 4-basket crate.

After packing, plums are usually moved directly into cold storage and cooled as rapidly as possible by stacking so as to allow maximum cold-air circulation through each container. Although it is desirable to cool plums to 32° F as rapidly as possible, most cooling facilities are not capable of reducing temperatures this low when large volumes of warm fruit enter in a short period. However, packers make every attempt to cool plums rapidly after packing because delays in cooling shorten the fruit's shelf life.

Once fruit is cooled it is loaded into rail cars or trucks. Cooling before loading is essential to insuring good arrivals because mechanical refrigerator cars or trucks may not be able to cool warm loads rapidly. If plums are to be stored rather than immediately shipped to market, the air-flow in storage is reduced after initial cooling to reduce moisture loss from fruit. The length of time plums can be stored depends on the variety, maturity, storage temperature, and relative humidity. Some varieties may be held from 2 to 4 weeks or longer under ideal cold storage conditions.

MARKETING

Although out-of-state markets are the major outlets for California plums, California has recently become an important market for its own production. Most plums are sold through independent or cooperative packer-shipper agencies, and growers are charged a sales commission based on the gross sales price received by the selling agency. Most sales are made on a FOB basis but auction sales are still used to set prices in some eastern American cities. The current trend is to sell directly to brokers or purchasing agents representing individual marketing firms, chain stores, or groups of chain stores.

The industry sales price is determined by a direct supply-demand relationship. Prices tend to fluctuate as day-to-day supplies change. Producers and handlers can adjust supplies to some extent by placing fruit in storage, but this alternative is restricted by a relatively short storage life for plums. Other factors responsible for price variation include consumer purchasing power, supplies of other fruits, and time of the season. Fruit quality, size, and container label also influence prices for specific fruit lots at any one time.

The term "quality" has many meanings: attractive appearance, handling without bruising, long shelf life, large fruit size, consumer acceptance, or a desired stage of maturity. Superior quality can result in prices well above the going market price on a specific day (this is proved by the confidence buyers have in certain labels or brands).

The shipping season starts with the Red Beaut variety in mid-May. Volume increases rapidly as the Santa Rosa variety, which can account for up to 25% of seasonal plum shipments, matures in June. If a heavy fruit set and pack of Santa Rosa occurs, it can have a depressing effect on plum prices later in the season by filling markets and storage facilities. The greatest volume of fruit is shipped in early and mid-July due to harvest of numerous varieties (i.e., El Dorado, Laroda, Nubiana). These are also subject to short term storage depending on market conditions. Shipments usually decline in late July but a substantial volume is packed during Casselman season in August. Most late season plums hold well in cold storage and fruit handlers use this to advantage in maintaining acceptable prices. Thus plums are marketed in volume from mid-May to early September.

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